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THE EFFECT OF IMMEDIATE VERSUS DELAYED DOWEL SPACE PREPARATION --ETC(U)

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This in vitro study evaluated the effect of immediate versus delayed dowel space preparation on the integrity of the apical seal. Twenty human teeth were obturated by lateral compaction of gutta-percha and cement, and stored. Two weeks later, twenty more were similarly filled. Using hot endodontic pluggers, dowel spaces were prepared such that either 3mm or 7mm of apical fill remained. The specimens were treated in $^{45}CaCl_2$, horizontally sectioned and autoradiographs made. Analysis of the incidence and degree of microleakage showed that delayed dowel preparations significantly increased leakage ($p=.01$) if only 3mm of apical fill remained.

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The Effect of Immediate
Versus Delayed Dowel Space
Preparation on Endodontically Filled Teeth

The Effect of Immediate Versus Delayed Dowel Space Preparation on Endodontically Filled Teeth

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ABSTRACT

This *in vitro* study evaluated the effect of immediate versus delayed dowel space preparation on the integrity of the apical seal. Twenty human teeth were obturated by lateral compaction of gutta-percha and cement, and stored. Two weeks later, twenty more were similarly filled. Using warm endodontic pluggers, dowel spaces were prepared such that either 3mm or 7mm of apical fill remained. The specimens were treated in $^{45}CaCl_2$, horizontally sectioned and autoradiographs made. Analysis of the incidence and degree of microleakage showed that delayed dowel preparations significantly increased leakage ($p<.01$) if only 3mm of apical fill remained.

Correct diagnosis, preparation and obturation of the root canal space are currently recognized as the basic principles which form the triad of endodontic therapy.[1] In a study by Ingle[2] more than two-thirds of all endodontic failures could be ascribed to inadequate preparation and obturation, with the latter accounting for nearly 59%. Therefore, the elimination of any portal of exchange between the root canal space and the periradicular area is of paramount importance for clinical success. During the process of dowel space preparation, however, many other factors may influence the ultimate prognosis of the case. The setting state of the cement, the alpha transformation of the gutta-percha, the operator's knowledge of the root canal space and his clinical ability to provide dowel space without radicular perforation are very important. The integrity of the root canal seal, however, must not be violated if one is to expect clinical success.

A great deal of controversy remains as to the most desirable depth of dowel space in endodontically treated teeth. Kemp,[3] Baraban,[4] and Frank[5] recommended that the dowel space be equal to the length of the restored clinical crown. Caputo and Standlee[6] advocated that at least 3mm to 5mm of gutta-percha remain undisturbed to insure the integrity of the apical seal. Neagley[7] did not observe any increase in incidence of leakage when 4mm to 8mm of the apical gutta-percha fill remained after immediate dowel space preparation. Schnell,[8] using fluorescent dye, found no statistically significant difference in loss of apical seal and leakage among teeth with immediate dowel space preparation and those with no space preparation. The incidence of leakage in each group was

approximately 66 percent. No delayed dowel space preparation was attempted in his study.

Seltzer[9] and Brady and del Rio[10] have shown that silver points corrode in the presence of body fluids. Neagley[7] demonstrated microleakage of Rhodamine B dye in 8 of 9 experimental teeth in which silver cones were reduced to 4mm during dowel space preparation. Thus the properties of plasticity and decreased dependence on intra-canal cement make gutta-percha a more desirable obturation material when dowel space is anticipated.

The purpose of this study was to investigate the effect of immediate and delayed dowel space preparation at various depths on the integrity of the apical seal in canals filled with laterally compacted gutta-percha and cement.

METHODS AND MATERIALS

Forty-seven, single rooted maxillary teeth were collected immediately following extraction and stored in 10% formalin solution. None had a root curvature of more than 20 degrees from the axial plane; furthermore, all had Class I root canal configurations of approximately the same diameter as viewed radiographically from the mesial aspect. Three hours prior to canal preparation, all teeth were placed in a solution of 1% sodium hypochlorite (Chlorox Corp., Oakland, CA) to remove any tissue tags attached to the root surface.

The crowns of all the teeth were reduced with high-speed burs and water spray until 15mm of root length remained. After removing the pulps with barbed broaches (Union Broach Corp, Long Island City, NY), #10 K-files (Sybron/Kerr Dental Products Division, Romulus, MI) were introduced until

they could be seen at the apexes. The working lengths were determined by subtracting 1mm from the actual root canal lengths.

In order to minimize the experimental variables, all of the subsequent procedures were performed by a single operator using clinically accepted methods. Employing a step-back preparation technique, the working lengths were prepared to the size of #50 K-files and the coronal portions of the canals flared. To insure patency, #10 K-files were passed through the main apical foramina between the uses of each successively larger instruments. Physiologic saline was used as the irrigating solution. The teeth were then randomly distributed into positive controls (2 teeth), negative controls (5 teeth) and four experimental groups (I-IV) of ten teeth each.

Canal obturation was performed in 45 teeth with lateral compaction of gutta-percha and non-staining root canal cement (Star Dental Mfg. Co., Conshohocken, PA). Specifically, #50 master cones were fitted to within 0.5mm of the working lengths and size A finger pluggers (Star Dental Mfg. Co., Conshohocken, PA) were adapted to within 2mm from the same reference. A thin layer of root canal cement was then coated on the canal walls as well as the apical dentin matrices by rotating #45 K-files counterclockwise. Following the placement of the master cones, #20 accessory cones (Sybron/Kerr Dental Products Division, Romulus, MI) were used during the lateral compaction phase. The excess filling material was removed from the coronal openings with warm endodontic pluggers Ransom & Randolph Co., Toledo, OH).

Positive Controls

In two teeth, the canals were instrumented but not filled. A dry

#2 cotton pellet was placed at the occlusal access of each and sealed with Cavit (Premier Dental Products Co., Norristown, PA). The teeth were wrapped in saline-soaked gauze, placed in closed bottles and incubated at 37 C for two weeks.

Negative Controls

The canals of five teeth were instrumented and obturated as described but no dowel space was created. The occlusal openings of each were similarly sealed and the teeth were stored in the same manner.

Group I

Ten teeth had dowel space preparations made immediately after obturation, leaving 3mm of apical filling material. Warm endodontic pluggers were used to remove the gutta-percha and moderate pressure was applied to the remaining apical fills. The occlusal portions were sealed with Cavit. The ten teeth were stored in physiologic solution and incubated at 37 C for two weeks.

Group II

Ten teeth had dowel space preparations made immediately after obturation, leaving 7mm of apical filling material. Warm endodontic pluggers were used to remove the gutta-percha and moderate pressure was applied to the remaining apical fills. As in Group I, these teeth were similarly sealed with Cavit, stored and incubated.

Group III

Ten teeth, after two weeks storage in physiologic solution, had dowel space preparations made with warm endodontic pluggers leaving 3mm of gutta-percha in the apexes. No intentional pressure was applied over the

remaining apical fills. The occlusal openings were sealed with Cavit.

Group IV

Ten teeth, after two weeks storage in physiologic solution, had dowel space preparations made with warm endodontic pluggers leaving 7mm of the apical fill. No pressure over the remaining gutta-percha was attempted. The occlusal openings were similarly sealed with Cavit.

Preparation Phase

The technique in the use of $^{45}CaCl_2$ for autoradiographic evaluation was a modification of that developed by Swartz and Phillips.[11,12] All teeth (forty-seven) were treated in the following manner. The occlusal surfaces were covered with dental sticky wax (Yates Mfg Co., Chicago, IL). The entire root surface, except the apical 2mm, was covered with aluminum foil and sticky wax. Care was taken to insure that the interface between the aluminum foil and the root at the apical area was sealed. The apical 2mm of the roots was not covered in order to evaluate the influence of accessory canals on the apical seal.

Immersion Phase

Each group of teeth was totally immersed in individual plastic bottles each containing 20 ml of .0717 mCi/ml $^{45}CaCl_2$ at 37 C for 3 hours. They were then washed under running water for 4 hours in order to minimize residual radioactive activity from the surface. After removing the sticky wax and aluminum foil, all roots were scrubbed with decontaminating solution and water for one minute and embedded in dental stone (Ransom and Randolph Co., Toledo, OH).

Twenty-four hours later all teeth were transversely cut on a Bronwill

sectioning machine (VMR Scientific, San Francisco, CA) with a 0.4mm thick diamond wheel (Norton Grinding Wheel Division, Worcester, MA) at intervals of 1mm from the root apexes. Copious amounts of water were utilized during the entire procedure to minimize the generation of heat. All sectioned specimens remained exposed to air for 24 hours to permit drying.

After discarding the initial 1mm apical sections (those beyond the working lengths which were not intentionally obturated), the surfaces representing 0.5mm, 1.5mm and 3.0mm distances from the working lengths (Figure I) were tightly pressed against dental ultra-speed periapical film (Eastmen Kodak Co., Rochester, NY) for 8 hours. All specimens were developed in an automatic processor (Philips Medical Systems, Inc., Shelton, CN) and evaluated for marginal leakage. In a preliminary study, the quality of autoradiographs was evaluated according to the exposure time between the film and specimens. Exposure times of 5, 8, 12, and 17 hours were evaluated. No observable difference was noted in the quality of autoradiographs using an exposure time of 8 hours as compared to 17 hours.

The evaluation was performed by three observers working independently projecting the autoradiographs at 20X on a viewing screen. Additional examination of both the autoradiographs and correlating tooth sections were made with a stereomicroscope (Wild Heerbrugg Ltd., Heerbrugg, Switzerland) from 6X to 50X magnification. The autoradiographs were evaluated and categorized according to the incidence and degree of circular microleakage.

Categories:

0 = No leakage (Figure 2a).

1 = Slight leakage; extension of leakage equal to or less than 90^{o} (Figure 2b).

2 = Moderate leakage; extension of leakage more than 90^{o} but less than 180^{o} (Figure 2c).

3 = Severe leakage; extension of leakage more than 180^{o} (Figure 2d).

4 = Very severe leakage in extension and width (Figures 2e and 2f).

RESULTS

The incidence of leakage in all groups is summarized in Table I. The two unfilled positive controls (Fig 3a and 3b) severely leaked whereas four of the five negatives showed no leakage (Fig 4a and 4b). The obvious minimal incidence of leakage occurred in groups II and IV at 1.5mm and 3.0mm from the working lengths. Using the Fisher's Exact Probability test, comparison between groups I and II at 1.5mm showed a statistical significance at $p<.009$; at 3.0mm it was dramatic. Similar analysis between groups III and IV showed a statistical significance of $p<.015$ with dramatic differences at 3.0mm. Thus leaving 7mm versus 3mm of apical fill is highly significant in both immediate and delayed dowel space preparations at 1.5mm and 3.0mm from the obturated working lengths.

Table II shows the distribution of specimens according to the degree of leakage using the 0 to 4 scale of formerly described leakage categories. One can easily observe the predominence of severe and very severe leakage in groups III and IV at the 0.5mm levels. By comparing the degrees of leakage (Table IIA) using the Mann Whitney U-test, a

statistical significance ($p<.02$) was calculated between these groups at the same level. Furthermore, a statistical significance ($p<.05$) between degrees of leakage of groups I and III at the 0.5mm level was shown.

The average effects and interactions of the two experimental factors, time of filling (immediate, delayed) and amount of apical filling left (3,7mm) were tested using a 2 x 2 analysis of variance in a completely randomized design and illustrated in Figure 5. Separate analysis was carried out for each of the three levels of sectioning. As shown in Table III, a significant difference in degree of leakage between immediate and delayed filled teeth occurred only at a level of 0.5mm from the working length ($F_{(1,36)} = 9.08$, $p<.01$). A constant direction of difference between teeth with 3mm versus 7mm of remaining apical fill occurred at each of the three levels. At 1.5mm and 3mm the differences were dramatic ($F>24.2$, $p<.001$). At 0.5mm the magnitude was smaller ($F = 9.08$, $p<.10$) but in the same direction. At none of the three levels was there any interaction effect. The effects of amount of apical filling left on the amount of leakage were similar for both immediate and delayed fill groups.

DISCUSSION

With the techniques and materials as outlined in this paper, there seems to be minimal leakage of radioactive tracer material. These results are in agreement with those of Allison et als.[13] but it should be stressed that in curved canals, where depth of penetration of the spreader is limited, the incidence of microleakage may be higher.

Among the experimental groups, the highest incidence and degree of microleakage was observed in those with only 3mm gutta-percha remaining

in the canal. This may be explained on bases of disturbance of the apical seal during physical manipulation. Conversely, the least incidence and degree of microleakage was shown in the group in which immediate dowel space preparation was done leaving 7mm of apical fill (Group II). The effect from time between obturation and dowel space preparation leaving 7mm of apical fill was not statistically significant (Table IIA and Fig 5).

After the evaluation of the autoradiographs and cut sections, no accessory canals were seen. Still, no conclusions can be made due to the limited number of sections. However, 7mm of gutta-percha in a canal will frequently not allow enough room for a post of an acceptable length. Further investigation is being conducted to determine the effect on apical leakage when more than 3mm but less than 7mm of apical fill remain.

During the dowel space preparation, it was observed that the removal of gutta-percha was more difficult in the delayed groups than in those receiving immediate dowel space. This could be explained on the bases of first, the set cement and second, the transformation of the gutta-percha into its alpha state in a relatively short period of time. It is therefore suggested that the clinician who performs the endodontic procedure also prepare the dowel space in accordance with the referral guidelines established with the restorative dentist.

This study is unusual because it showed not only the incidence of microleakage, but also the additional parameter of degree of radioisotopic ingress; thus, a more accurate picture of total leakage can be appreciated. It must be emphasized, however, that clinical correlation is extremely difficult because isotopes may not be equated with exotoxins and other

factors which relate to clinical failure. Nevertheless, it still provides us with a valuable research tool with which we can assess microleakage patterns.

SUMMARY AND CONCLUSIONS

Forty-seven single-rooted maxillary teeth were instrumented using a stepback technique, of which 45 were obturated. Twenty teeth had dowel spaces prepared immediated after fill, leaving 3mm and 7mm of apical fill in each group of ten respectively. Twenty teeth were similarly prepared for dowel spaces but after a two-week interval. Five teeth were designated as negative controls in which the canals were filled but no dowel spaces were prepared. Two other teeth were used as positive controls to test the diffusibility of the isotope. All specimens were immersed in a solution of $^{45}CaCl_2$ and transversely sectioned at 0.5mm, 1.5mm, and 3mm distances from the working lengths. Autoradiographs were taken for the detection of microleakage. The data was analyzed to show both the incidence and degree of leakage as defined by categories of circular isotope ingress.

Based on the findings from this study, it can be concluded that:

1. At all examined distances from the canal working lengths, seven millimeters of remaining apical fill resulted in less disturbance of apical seal than did three millimeters.

2. At 0.5mm from the canal working lengths, immediate dowel space preparation significantly decreased the degree of microleakage ($p<.01$) as compared with delayed space preparation in which 3mm of apical fill remained.

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Table I

INCIDENCE OF LEAKAGE

Distance*	+Control	Neg Control	Grp I Immed 3	Grp II Immed 7	Grp III Delayed 3	Grp IV Delayed 7
0.5	2	1	9	6	10	10
1.5	2	0	7	1	8	2
3.0	2	0	7	0	6	0

*Distance of cut surface from working length.

Table II

DISTRIBUTION OF SPECIMENS
ACCORDING TO THE DEGREE OF LEAKAGE
AND LEVELS

LEVELS	CONTROLS					Immed 3mm I					Immed 7mm II					Delayed 3 III					Delayed 7 IV				
	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
0.5mm	4	0	0	1	0	1	2	3	2	2	4	0	0	6	0	0	0	0	4	6	0	2	1	6	1
1.5mm	5	0	0	0	0	3	2	1	3	1	9	0	0	1	0	2	0	0	6	2	8	2	0	0	0
3.0mm	5	0	0	0	0	3	3	1	2	1	10	0	0	0	0	4	1	0	5	0	10	0	0	0	0

Table IIA

Degree of Leakage Comparisons*

	I vs II Immed 3 vs Immed 7	I vs III Immed 3 vs Delayed 3	II vs IV Immed 7 vs Delayed 7	III vs IV Delayed 3 vs Delayed 7
0.5mm	NS	.05	NS	.02
1.5mm	.05	NS	NS	.02
3.0mm	.05	NS	NS	.05

*Using Mann Whitney U-test for comparison of ranked data.

TABLE III

Summary of Analysis of Variance for Each Level

Comparison		LEVEL IN mm				
		0.5	1.5	3.0	0.5+1.5+3.0	1.5+3.0
Immed vs Delay	F	9.08	1.19	<1	2.52	<1
	P	<0.01	NS	NS	--	--
3mm vs 7mm	F	3.68	26.94	24.2	21.64	29.52
	P	<0.10	<0.001	<0.001	<0.001	<0.001
Interaction	F	<1	1.87	<1	<1	<1
	P	NS	--	--	--	--
MS error (36DF)		1.33	1.34	1.13	8.35	4.27

F = observed F ratio with 1,36 degrees of freedom
P = significance level (p-value)

LEGEND

Figure 1	Schematic drawing of evaluated cut surfaces in millimeter distances from the obturated working lengths.
Figure 2a	Autoradiographs illustrating degrees of microleakages. 0 = No leakage.
Figure 2b	1 = Slight leakage; equal to or less than 90^{o}.
Figure 2c	2 = Moderate leakage; more than 90^{o} but less than 180^{o}.
Figure 2d	3 = Severe leakage; more than 180^{o}.
Figures 2e, 2f	4 = Very severe leakage; more than 180^{o} plus an increased width of ingress.
Figure 3a	Radiograph of positive control.
Figure 3b	Autoradiograph of positive control showing very severe leakage.
Figure 4a	Radiograph of negative control.
Figure 4b	Autoradiograph of negative control showing no leakage.
Figure 5	Histograms showing the average of the degrees of leakage.

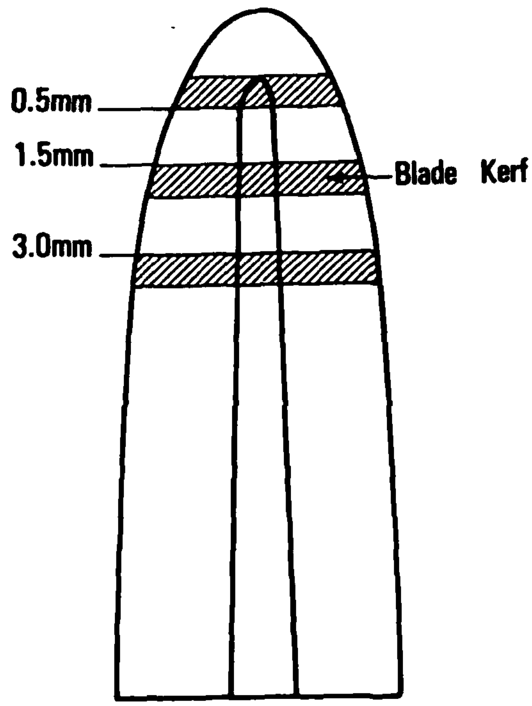

FIGURE 1

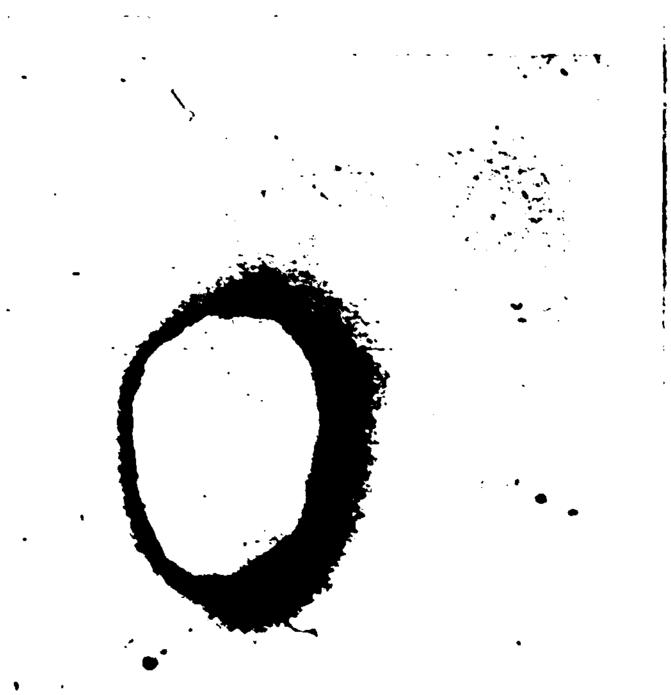

FIGURE 2a

FIGURE 2b

FIGURE 2c

FIGURE 2d

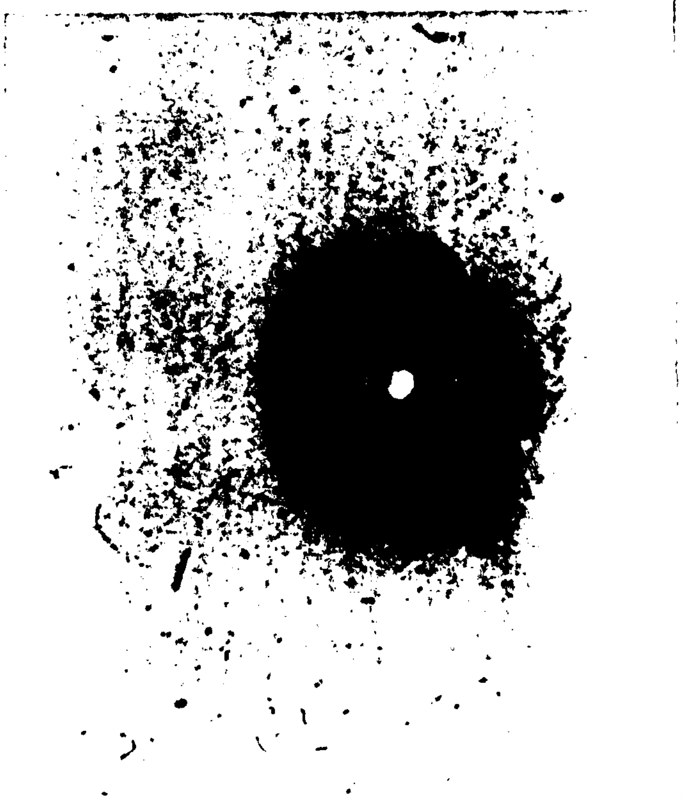

FIGURE 2e, 2f

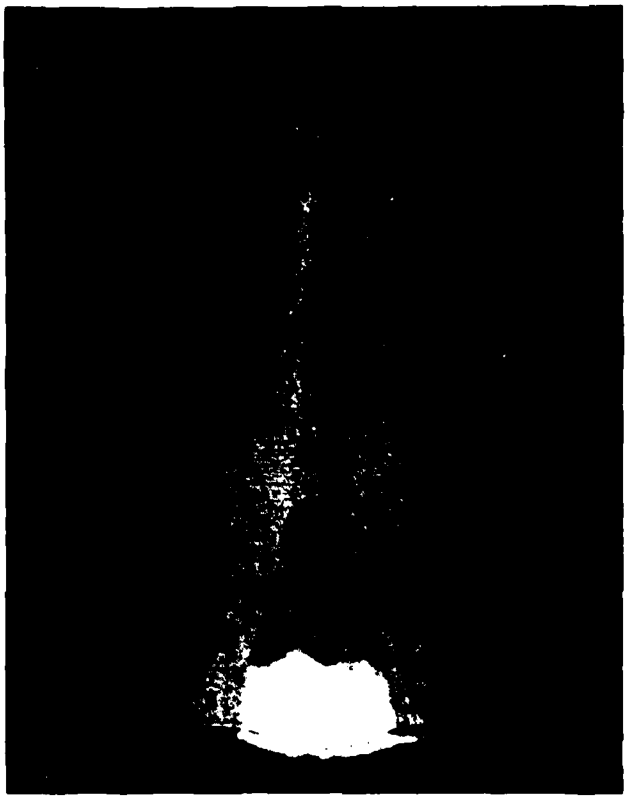

FIGURE 3a

FIGURE 3b

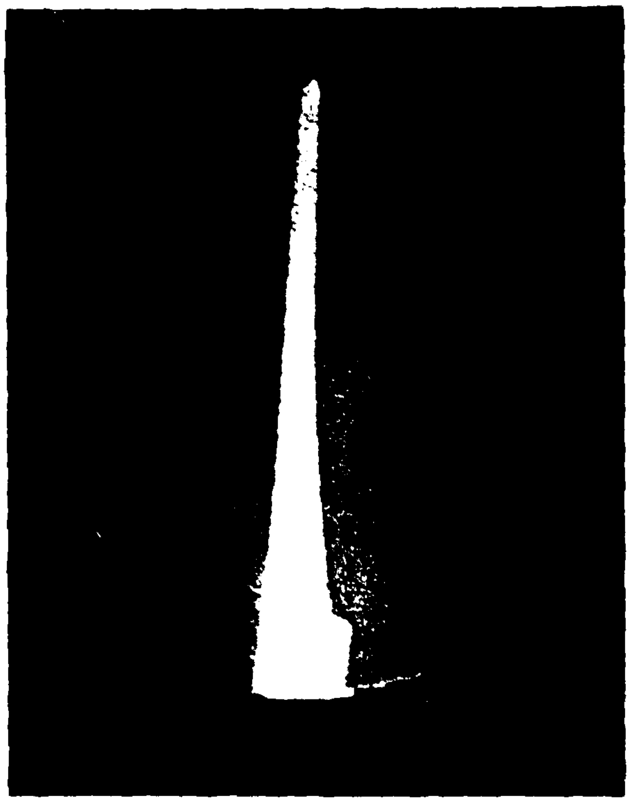

FIGURE 4a

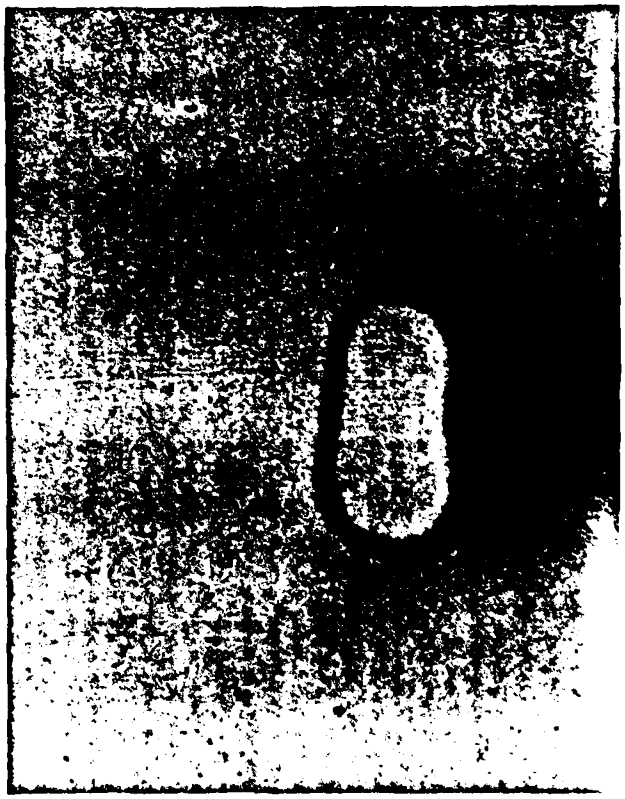

FIGURE 4b

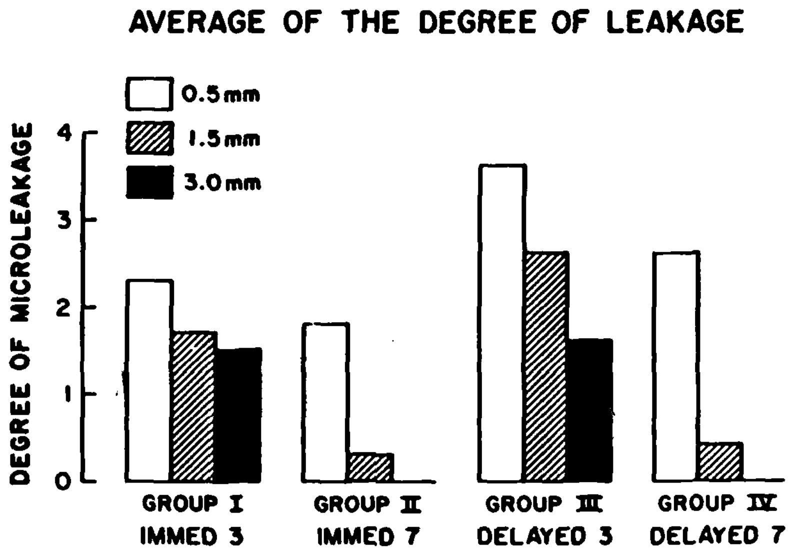
AVERAGE OF THE DEGREE OF LEAKAGE
0.5mm
1.5mm
3.0mm
DEGREE OF MICROLEAKAGE
0
1
2
3
4
GROUP I
IMMED 3
GROUP II
IMMED 7
GROUP III
DELAYED 3
GROUP IV
DELAYED 7

FIGURE 5